NOVEMBER 2004 SPACE WEATHER EVENTS
REAL TIME OBSERVATIONS AND FORECASTS

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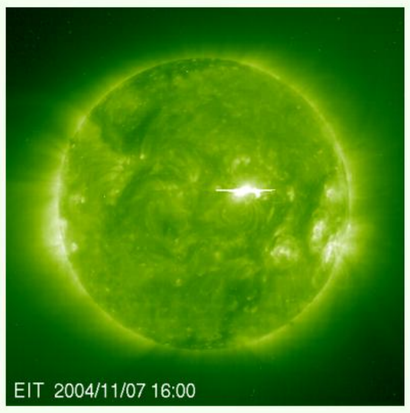
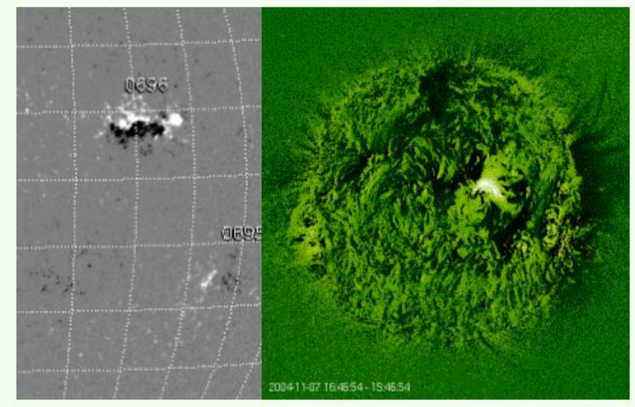
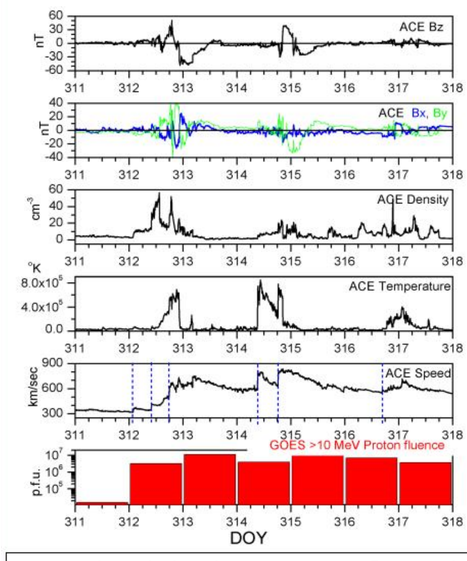


Monitoring Space Weather events on the basis of real-time observations is an important tool for forecasting needs as well as for scientific purposes. This poster is a collective work based on the materials presented at the Splinter Session during the first ESWW in November 2004.

The complexity of the November 2004 Space Weather events was pre-defined by the 9 coronal mass ejections forming two geo-effective interplanetary structures. Rapid extensive expansion of the auroral oval to 55 degrees in geomagnetic latitude and the great variability of the ionosphere became the sources of difficulties for forecasters.





ACE solar wind and GOES proton fluence data

INTERPLANETARY PROPAGATION REAL TIME DATA

Four CMEs of 3-4 November (see the table) interacted on their way producing a complex ICME, which passed the ACE location on 7-8 Nov. (DOY 312-313) demonstrating 3 shocks and magnetic cloud (MC) structure.

Three CMEs of 6-7 November (table) gave a complex ICME of 9-10 Nov. (DOY 314-315) at the L1 location with 2 shocks and MC structure.

Both ICMEs contained long periods of strong (~ –50nT) southward interplanetary magnetic field (IMF).

CME of 9th November produced a not well-defined structure on 11-12 November with one small shock.
CME of 10th November did not reach the L1 location.

Daily proton fluence at GOES experienced abrupt increase due to X2.0 flare on 7th November and stayed elevated until November 17th .

Date	CME (time of 1st appearance in LASCO C2, FOV speed)	Peak of accompanying flare	Interplanetary structure
3 November	03:54, partial halo, 750 km/s	M1.6, 03:35	Probably did not arrive, origin is far from central meridian
3 November	16:06, full halo, 1016 km/s	M5.0, 15:47	Shock 01:53, 07 Nov.
4 November	09:54, partial halo, 635 km/s	C6.3, 09:05	Shock 10:07, 07 Nov.
4 November	23:30, partial halo, 1053 km/s	M2.5, 22:29 M5.4, 23:09	Shock 17:53, 07 Nov.
6 November	01:31, partial halo 960 km/s,	M9.3, 00:34 M5.9, 00:57 M3.6, 01:57	Shock 09:14, 09 Nov.
7 November	17:06, full halo 1770 km/s	X2.0, 16:06	Shock 18:40, 09 Nov.
8 November	04:06 08.11, full halo, 520 km/s	C7.9, 03:29	Probably swept by the following fast CMEs
9 November	17:26 09.11 full halo, 1853 km/s,	M8.9, 17:19	Shock 16:44, 11 Nov
10 November	02:26 10.11, full halo 1975 km/s,	X2.5, 02:13	Probably did not arrive, origin is far from CM

Full and partial halo CMEs produced by AR 0696 in November 2004

ICME ORIENTATION FORECAST

The main neutral line in the active region (AR) 0696 shows East-West direction during its whole passage through the solar disk (top figure left panel) with positive polarity on northern side. Therefore, south-north orientation of the large scale magnetic field of the flux rope with leading south edge was forecasted for the second partial halo CME of 4th November (RWC Brussels) and confirmed by SEN orientation of the first ICME seen at ACE.

The second ICME was expected to have a similar orientation of the magnetic field as being produced by the same AR, but showed rather a NWS direction (see ACE plots). This can be the result of more complicated magnetic field orientation (see the difference image on the top right panel) with disappearing filament hidden below loops, connecting AR 0696 and AR 0695. The orientation of the magnetic field of this filament flux rope was most likely NWS, with 45° inclination to the E-W which later was encountered by ACE. Prediction in this case was impossible.

POLAR IONOSPHERE TEC REAL TIME

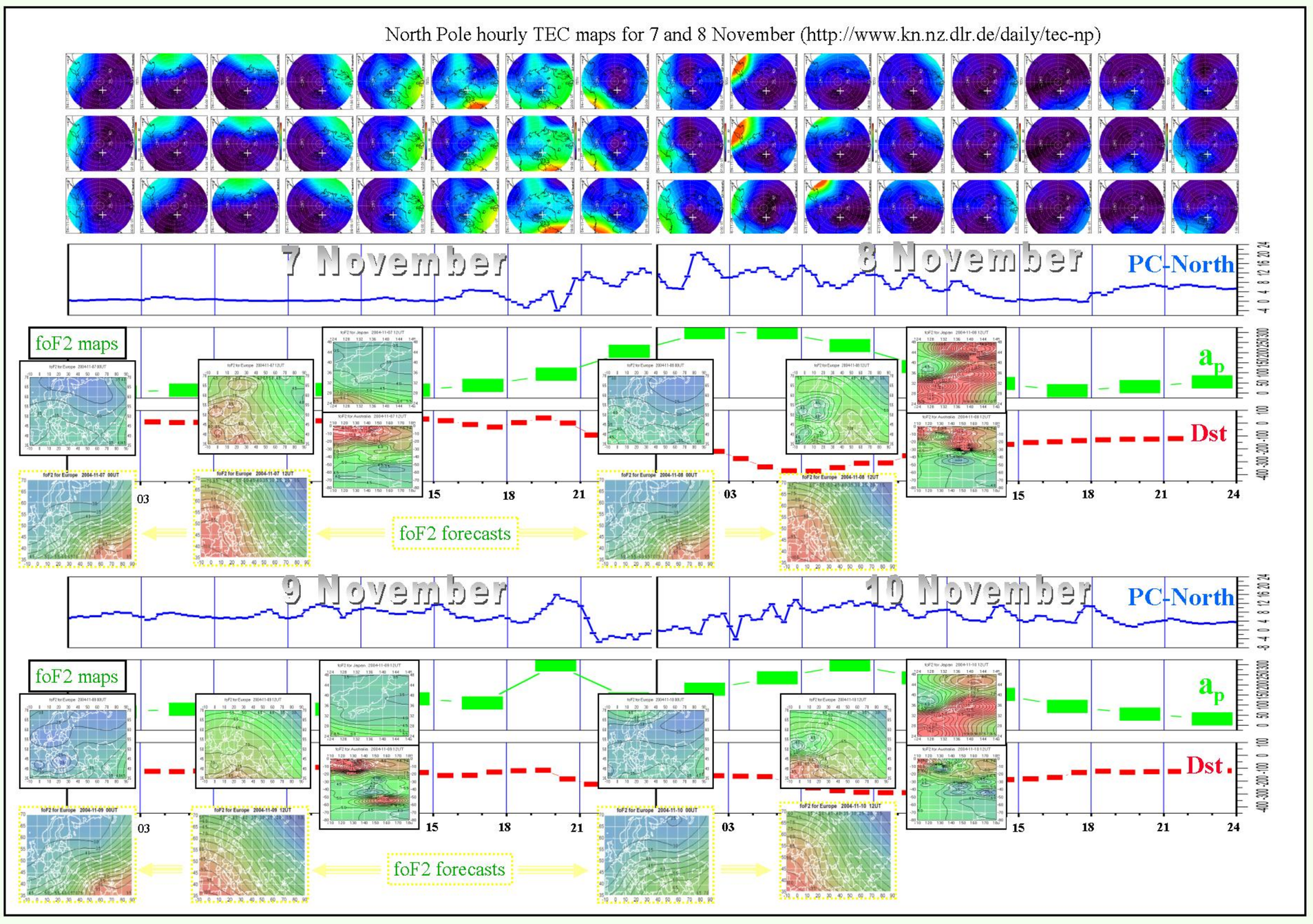
Indications of the upcoming storm started to appear on TEC polar maps from 12:00 UT on 7th November. In addition to the strong overall elevated TEC, a near-pole patch of increased ionization can be noted. This feature grows in size and propagates southward over the night side.

During the night and morning hours of 8th November the ionosphere was severely perturbed with extremely high polar TEC over dayside in 04:00 – 06:00 UT.
The depletion of the ionosphere started around 08:00 UT and signified the recovery phase of this first storm.

GLOBAL foF2 MAPS DATA AND FORECAST

The complicated signatures of the perturbed foF2 were observed in Europe, Japan and Australian regions. They are presented as black-framed maps of the critical frequency of F2 layer (foF2), The maps of forecasted foF2 (yellow-framed) are shown for European continent. These maps were prepared by RWC Warsaw.

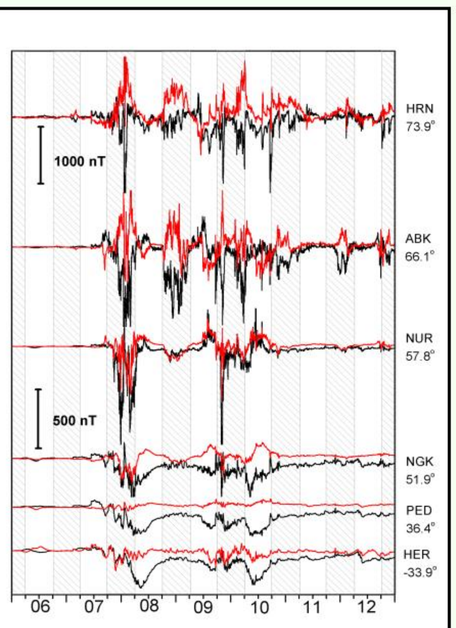
7 November:
00:00 UT "post-factum" foF2 lower than predicted.
12:00 UT increased foF2 in Northen Europe due to the auroral activity upcoming storm, night-time (Japan and Australia) show regular pattern.
8 November:
00:00 UT Decreased nighttime foF2.
12:00 Decreased day time foF2 with complex patterns. Increased night equatorial values (Japan, fountain effect?) and complex patterns over Australia.
9 November:
00:00 UT Decreased nighttime foF2.
12:00 Almost regular day time maps, decreased night time equatorial (Japan) and still complicated Australian region.
10 November
00:00 UT Decreased nighttime foF2.
12:00 UT Small structures for European region (UK), increased night equatorial (Japan) and complex patterns over Australian region.
Forecast for most of the time were quite different from data and can serve only as average pattern.



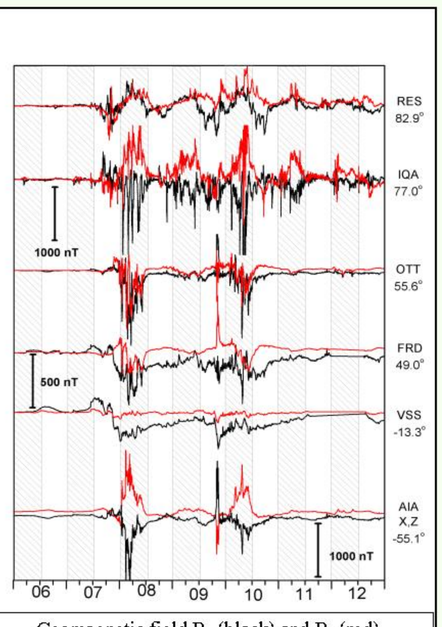
GLOBAL GEOMAGNETIC FIELD REAL TIME

The first complex ICME of 7-8 Nov. produced 2 SI, and turning IMF southward followed by the strong geomagnetic storm. It started at the day side with eastward auroral current system and changed to the night side westward auroral electrojet system located between 66° and 57.8° geomagnetic latitude. Auroral activity strongly influence lower latitude stations and can be seen at NGK (Europe). In American sector the expansion of auroral oval can be seen almost down to 50°.
The next night of 8-9 Nov. shows enhanced activity in traditional auroral zone due to the high speed solar wind passage.

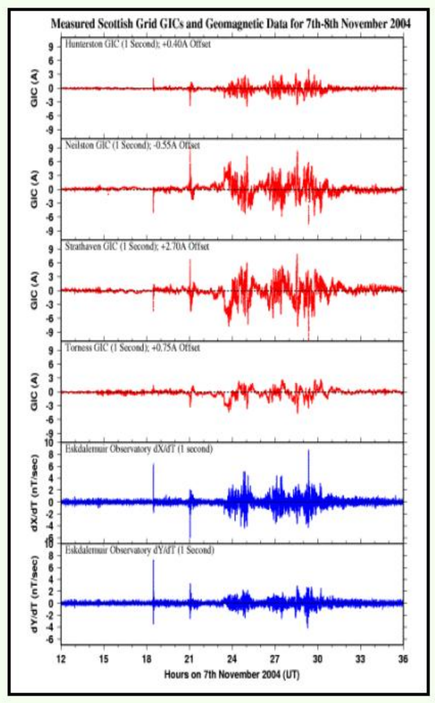
The second complex ICME of 9-10 Nov. caused the second geomagnetic storm, with its main phase started right after midnight when IMF Bz turned negative for a long period of time. It is characterized by an enhanced westward auroral electrojet at night side. Prior to that, sharp short negative Bz turning at 18:00, 9th Nov. produced short duration eastward electrojet near OTT and conjugate at AIA and westward between ABK and NUR.
The activity continues through the daytime 10th Nov. and next night in auroral zone due to the continuously high speed of the solar wind.

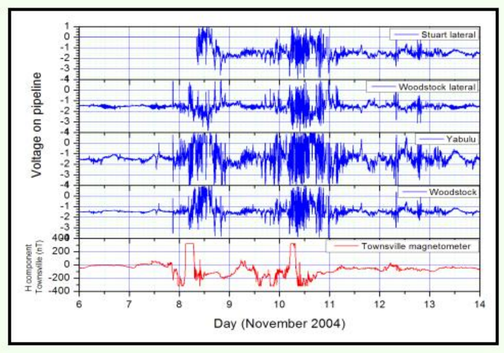


Geomagnetic field B_x (black) and B_z (red) components at observatories in Europe and Africa



Geomagnetic field B_x (black) and B_z (red) components at observatories in America and Antarctica





EFFECTS ON POWER SYSTEMS AND PIPELINES

GIC in Scottish Power grid (left panel) were recorded and investigated by BGS. These show close relationships with geomagnetic rate-of-change, especially in the high frequency part of the disturbances, such as sudden impulses (SI).

The large geomagnetic bays observed in Australia were accompanied by the large telluric currents in low latitude (~28° dip) gas pipeline, taking them well outside the operational range (top panel). These events are now studied by RWC Australia.